

This Page Is Inserted by IFW Operations
and is not a part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

**As rescanning documents *will not* correct images,
please do not report the images to the
Image Problem Mailbox.**

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

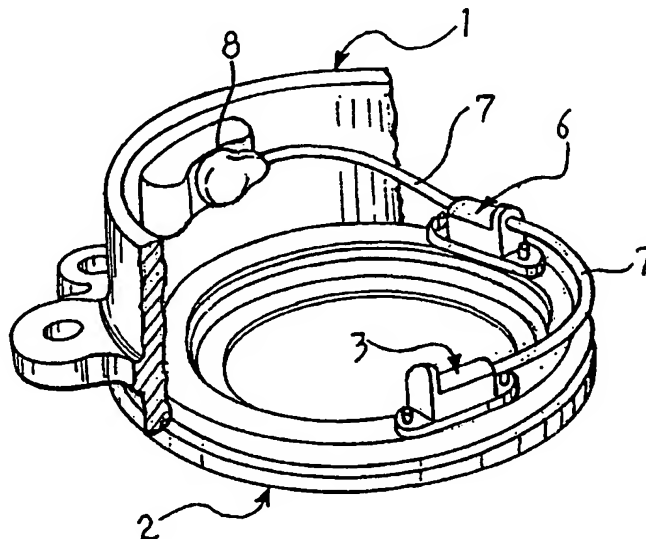

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁷ : B61K 9/12, 9/04, B61F 15/20, G01M 13/04		A1	(11) International Publication Number: WO 00/51869
			(43) International Publication Date: 8 September 2000 (08.09.00)
(21) International Application Number: PCT/EP00/01690		(81) Designated States: AU, CA, JP, KR, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).	
(22) International Filing Date: 29 February 2000 (29.02.00)			
(30) Priority Data: TO99A000164 4 March 1999 (04.03.99) IT		Published With international search report.	
(71) Applicant (for all designated States except US): SKF INDUSTRIE S.p.A. [IT/IT]; Via Arcivescovado, 1, I-10121 Torino (IT).			
(72) Inventors; and (75) Inventors/Applicants (for US only): MORETTI, Roberto [IT/IT]; Via Martiri della Libertà, 33/10, I-10020 Cambiano (IT). SEMA, Silvano [IT/IT]; Via Dante Alighieri, 2, I-10060 Cercenasco (IT). GENERO, Matteo [IT/IT]; Via Sambuy, 99, I-10026 Santena (IT).			
(74) Agents: FIORAVANTI, Corrado et al.; Jacobacci & Perani S.p.A., Corso Regio Parco, 27, I-10152 Torino (IT).			

(54) Title: A RAILWAY AXLE HUB UNIT

(57) Abstract

A railway axle hub unit of the type comprising an axle box housing (1) for supporting a bearing, is provided with a sensor body (3, 9) containing sensors (4, 5) for detecting vibration in the vertical direction and the horizontal axial direction. The sensor body is mounted onto a stationary support element (2, 1, 15) rigidly secured to the bearing, preferably an annular sealing insert. The sensors perform monitoring of the operation condition of the hub unit by generating and transmitting signals indicative of the detected level of vibration to an electronic processing unit mounted on board of the railway vehicle or the train. The processing unit is capable of signalling in real time an impending failure and/or a damaged condition associated with the monitored hub unit.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

WO 00/51869

1

PCT/EP00/01690

A railway axle hub unit

Technical Field

The present invention refers to a railway axle hub unit of the type comprising an axle box housing for supporting a bearing.

Background Art

Mechanical deterioration of the axle supporting bearings, besides adversely affecting the operational performance of the axle, also reduces the safety of the vehicle and may lead to the failure of the bearing, with catastrophic consequences such as derailment.

The main structural or functional defects which bearings of the above kind or the relative wheel are subject to can be summarised as follows:

- manufacturing or assembling defects of the bearing, which provoke an excessive play between its components (inner and outer raceways, rolling bodies, retaining cages, sealing devices, shoulders defining the axial position of the bearing with respect to the axle); cracks or spalls due to fatigue; local pitting due to an electrical current passing through the bearing; rust marks;
- insufficient lubrication of the inner parts of the bearing; polluted or deteriorated lubricant;
- flats in the rolling surface of a wheel due to the wheel being locked while the railway vehicle is travelling; excessive wear of the wheel profile in the rail contact zone;
- axial play of the wheel with respect to the axle, whereby the rotation axis of the wheel is not perpendicular to a

WO 00/51869

2

PCT/EP00/01690

vertical plane.

Up to now methods of checking the conditions of the bearings have been limited to periodical maintenance interventions. With such interventions, all the bearings of a same vehicle are replaced regardless of their conditions, including bearings being still valid and not needing to be replaced.

It will be understood that this way of proceeding first of all involves high costs of labour and passive costs for leaving the vehicle unused, but above all it does not allow to predict or detect the occurrence of failures in time before the bearing is so deteriorated to represent a condition of potential danger. Therefore, there is the risk of continuing to use a defective bearing or wheel for prolonged periods till the moment set by the maintenance schedule for replacement.

U.S. Patent No. 5,433,111 discloses an apparatus for detecting defective conditions associated with a set of railway vehicle wheels and with a railtrack upon which a given railway vehicle travels. The apparatus comprises measurement means for generating data indicative of rotational rate of the wheels, a set of accelerometers adapted to generate data indicative of motion along three orthogonal axes, wherein one of the axes is generally vertical with respect to the railtrack, and a data processor adapted to detect, based on the received rotational rate and motion data, a defective condition associated with at least one wheel of the vehicle.

U.S. Patent No. 5,381,692 refers to a monitoring system of a bearing assembly for supporting the drive shaft of a helicopter. The system has a vibration sensor for providing signals indicative of the vibrations emanating from the bearing as-

WO 00/51869

3

PCT/EP00/01690

sembly, first temperature sensing means for providing signals indicative of the bearing assembly operating temperature and second temperature sensing means for providing signals indicative of the ambient temperature. An alarm subsystem in response to the vibration and temperature signals provides an alarm signal warning of degradation condition of the bearing.

Disclosure of Invention

It is an object of the present invention to predict and/or identify in time and give a warning of the presence of a defect, the kind of defect and its precise location, in particular distinguishing which wheel of the vehicle or train is affected by the defect, and more particularly distinguishing whether the defect is affecting the wheel, its bearing or one of the components of the latter.

Another object of the present invention is to provide a continuous and real time monitoring of the operating condition of the bearing to obtain real time information concerning the variation of the defect in time, so that it is possible to intervene with urgency for severe failures, or delay intervention depending on the gravity of the detected failure, or consider the opportunity of not intervening, for example when an operation defect is stabilised or is stabilising.

Another object of the invention is to optimise maintenance, so as to intervene only when it is appropriate or necessary, and replace only the bearing individuated as defective or worn out.

These and other objects, which will be better understood herein after, are achieved according to the present invention by a railway axle hub unit of the type comprising an axle box

WO 00/51869

4

PCT/EP00/01690

housing for supporting a bearing, characterised by being equipped with sensor means for detecting vibration in a generally vertical direction, said sensor means being mounted onto a stationary support element rigidly secured to the bearing, said sensor means being adapted for generating and transmitting signals indicative of the detected level of vibration to an electronic processing unit on board of the railway vehicle or the train, whereby said processing unit is capable of signalling in real time an impending failure and/or a damaged condition associated with said monitored hub unit.

A further object of the invention is to provide a hub unit equipped with vibration sensors located at an optimal position for detecting the vibrations which the bearing and the wheel are subjected to, and for individuating correctly the nature, the location and the extent of possible defects.

This object is accomplished by a hub unit having the features defined in claims 2 to 4.

Further important features are defined in the other depending claims.

Brief Description of Drawings

The characteristics and advantages of the invention will become apparent from the detailed description of a few embodiments thereof with reference to the appended drawings, provided purely by way of non-limiting example, in which:

- figure 1 is a perspective view, with some parts broken off, showing the inside of a housing of the bearing and sensors unit according to the present invention;
- figure 2 is a perspective view, with some parts broken

WO 00/51869

PCT/EP00/01690

5

- off, showing the outside of the housing of figure 1;
- figure 3 is a perspective view, to an enlarged scale, of a sensor carrier body equipped with two vibration sensors oriented in different directions;
 - figures 4 and 5 are front views schematically showing two respective variants of the sensor carrier body of figure 3; and
 - figure 6 is a partial cross sectional view of a further variant of a sensor carrier.

Modes for Carrying Out the Invention

Referring initially to figure 1, numeral 1 designates overall a substantially cylindrical bearing housing fixable in known manner to a railway vehicle for supporting a rolling contact bearing housed therein and not shown for simplicity.

A metal annular insert 2, adapted for sealing the bearing from the outboard side, is press fitted onto the radially outer race (indicated 17 in figure 6) of the axle bearing. Preferably, the sealing insert 2 is made of cold forged steel plate about 2 mm thick.

With reference also to figure 3, in accordance with the invention, mounted on the sealing insert 2 is a sensor body 3 containing a bi-directional accelerometer device comprised of a first accelerometer 4 oriented in the vertical direction and a second accelerometer 5 oriented in the horizontal axial direction.

Advantageously, the sensor body 3 is positioned on the sealing insert 2 at a position vertically aligned with the axis of rotation of the bearing, where the vibrations are more intense. Preferably, the sensor body is positioned in the

WO 00/51869

PCT/EP00/01690

6

higher part of the insert (in other words at 12 o'clock), i.e. in correspondence of the zone where the rolling bodies of the bearing undergo the maximum load.

The sensor body 3 forms a base portion 3a for resting onto a radial surface 2a of the sealing insert 2, with a pair of bores 3b for allowing the passage of respective fastening elements (not shown) for securing in removable manner the sensor body 3 to the insert 2.

The accelerometers 4 and 5 are preferably of the piezoelectric type, associated with respective amplifiers (not shown) incorporated in the sensor body.

The accelerometer 4 detects vertical vibrations which the bearing/wheel assembly is subjected to. The accelerometer 5 serves to detect horizontal vibrations provoked by the wheel rim hitting against the rail as the vehicle oscillates along the track.

In the example shown in figure 1, a further sensor body indicated overall at 6 is mounted on the sealing insert 2 at a location distinct from where the sensor body 3 is fitted. The sensor body 6 incorporates motion sensors, such as a rotational speed sensor detecting the passage of the poles of a magnetised ring rotating fast with the rotating race of the bearing, and possibly other motion sensors such as a sensor for detecting the direction of rotation.

Differently from what is shown by way of example in figure 1, all the sensors which the housing is equipped with may be incorporated in a single sensor body 3, as shown in figure 3. In this case the sealing insert 2 has an aperture (not shown) at the location of sensor body 3 for allowing the motion sen-

WO 00/51869

PCT/EP00/01690

7

sors to face the aforesaid magnetised ring.

In a preferred embodiment, besides the vibration and motion sensors, also a temperature sensor (not shown) is included for signalling the occurrence of temperatures higher than those of normal operation and indicating that the friction within the bearing is exceeding a pre-set threshold value of admissibility.

The signals generated by the various sensors are transmitted through a cable 7 to a multi-pin connector 8 mounted on the same housing 1.

From the connector 8, the various signals from the various sensors are transmitted to an electronic processing unit (not shown) mounted on board of the railway vehicle or train. Said unit processes the received signals and is provided with suitable software adapted for recognising conditions of defective operation, such as e.g. excessively high temperature or irregular vibration frequencies related to determined defects, and once a defect has been detected, signalling its presence and variation with time.

When at least one of the signals related to one of the monitored parameters exceeds a predetermined threshold level, the processing unit generates an alarm signal that allows to intervene at the right moment to remove the defect and restore conditions of safe and correct operation.

The parameters may indifferently be monitored continuously or periodically, according to requirements or to the gravity of the defect possibly detected.

According to an alternative embodiment of the invention,

WO 00/51869

PCT/EP00/01690

8

shown in figures 4 and 5, the sensor body may have the shape of a hollow cylinder 9 adapted to be secured, for example by screwing, in a recessed seat 10 formed directly in the housing 1. A capsule 11 containing the above sensors is locked within the cylinder 9.

In the variant of figure 4, the seat 10 is formed and dimensioned with two different diameters so that the sensor body 9, once fitted in the seat 10, remains flush with the outer surface 12 of the housing 1.

In the variant of figure 5, the cylindrical body 9 is designed to project outwardly of the housing and is coupled thereto by means of a lower threaded portion 13.

In the variant of figure 6, a flange portion 9a is integrally formed with the sensor body 9. The flange portion 9a serves to rest and fix the sensor body 9 onto an outer surface 14 of the housing 1 or, as is the case of the example of figure 6, a cover member 15 that closes the housing 1 on the outboard side. The flange portion 9a has a pair of bores 16 (only one of which is shown in figure 6) for accommodating fastening elements, for example screws or bolts, for removably securing the sensor body 9 to the cover member 15 (or the housing 1). In this way the sensor body is accessible from the outside whereby it can be removed easily for overhauling or replacing the sensors. Furthermore, the variant of figure 6 is advantageous in that it is applicable to any kind of conventional axle unit. In figure 6, numeral 17 designates the outer, stationary race of the bearing, and numeral 18 designates the inner race rotating fast with the axle 19 and an impulse ring or phonic wheel 20. A sensor (not shown) for detecting the rotational speed of axle 19 is mounted in the radially inner end portion 9b of the sensor body 9 and projects through an open-

WO 00/51869

PCT/EP00/01690

9

ing 15a of the cover member 15 so as to operationally face the impulse ring 20. It should be noted that the sensor body 9 may also accommodate a temperature sensor and/or other motion sensors of known kind.

It will be appreciated that the present invention allows to identify the precise location and nature of a defect, and to distinguish and distinctly signal the several defects listed in the introductory part of the description. The processing unit software is capable of distinguishing whether vibrations are caused by defects of the bearing/wheel assembly or simply due to the passage of the vehicle over deflected rails or switches.

Locating the vibration sensors at the shield of the sealing device has turned out to be particularly advantageous, especially for reading vibration signals. Whilst it is not desired to be bound to any specific theory in this connection, tests carried out by the Applicant show that the sealing insert, by virtue of its stiff and thin structure intimately fixed to the bearing, constitutes an ideal path for the transmission of vibration.

Moreover, locating the sensors on the sealing insert keeps some space free within the housing to be possibly used for mounting therein a power generator for supplying current to the electronics for analysing the monitored signals. This possibility is of particular interest for applications on wagons having no electric supply.

While only certain features of the invention have been described and illustrated herein, many modifications, substitutions, changes and equivalents will now occur to those skilled in the art. For example, the detected signals can be

WO 00/51869

10

PCT/EP00/01690

transmitted by wire or radio transmission to a general processing unit located in a remote position, e.g. in the driver's cab.

WO 00/51869

PCT/EP00/01690

11

CLAIMS

1. A railway axle hub unit of the type comprising an axle box housing (1) for supporting a bearing, characterised by being equipped with sensor means (4) for detecting vibration in a generally vertical direction, said sensor means (4) being mounted onto a stationary support element (2, 1, 15) rigidly secured to the bearing, said sensor means being adapted for generating and transmitting signals indicative of the detected level of vibration to an electronic processing unit on board of the railway vehicle or the train, whereby said processing unit is capable of signalling in real time an impending failure and/or a damaged condition associated with said monitored hub unit.
2. A hub unit as claimed in claim 1, characterised in that said stationary support element is a sealing annular insert (2) of sheet metal secured to the stationary outer race of the bearing.
3. A hub unit as claimed in claim 1, characterised in that said sensor means (4) are mounted onto said stationary support element (2, 1, 15) at a position vertically aligned with the axis of rotation of the bearing.
4. A hub unit as claimed in claim 3, characterised in that said sensor means (4) are mounted onto said stationary support element (2, 1, 15) at a position vertically aligned above the axis of rotation of the bearing.
5. A hub unit as claimed in claim 1, characterised in that said sensor means (4) are incorporated in a sensor body (3, 9) further including sensor means (5) for detecting vibration in a horizontal, axial direction.

WO 00/51869

PCT/EP00/01690

12

6. A hub unit as claimed in claim 1, characterised in that it further comprises sensor means for detecting the temperature of the bearing.

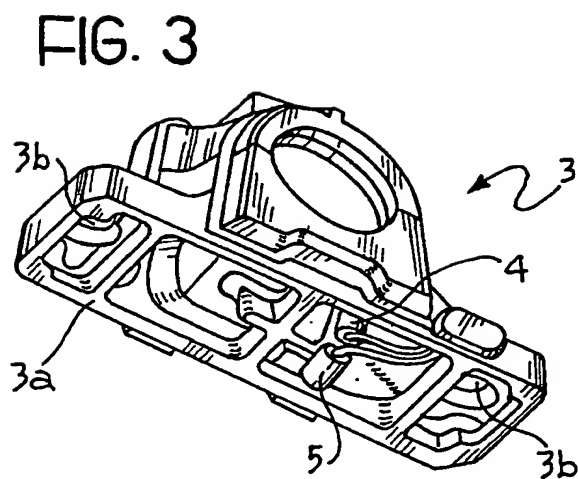
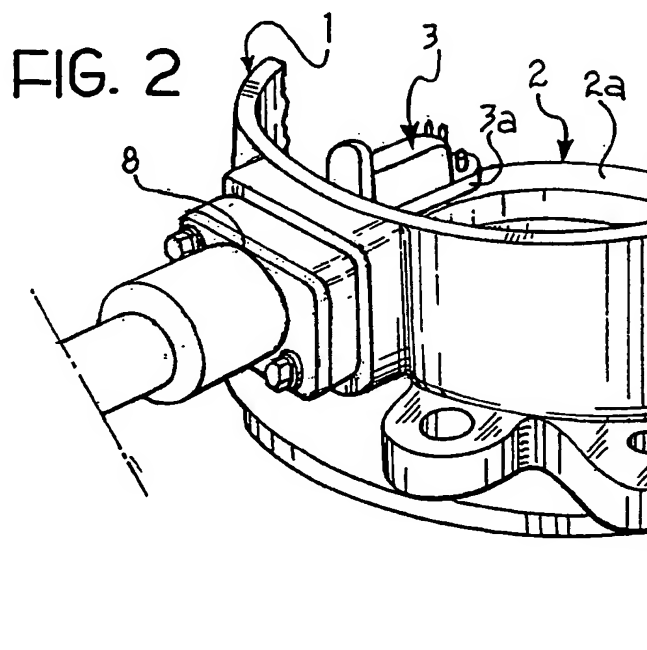
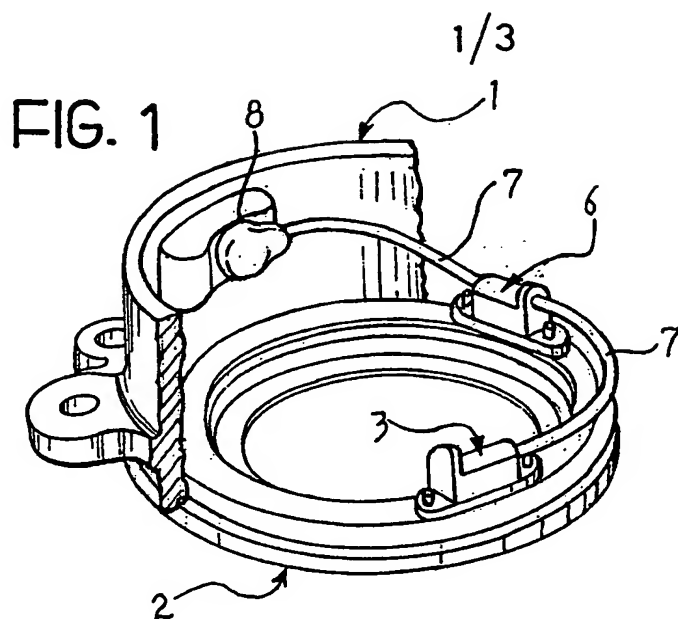
7. A hub unit as claimed in claim 1, characterised in that it further comprises sensor means for gauging the rotational speed of the axle and/or the direction of rotation of the axle.

8. A hub unit as claimed in any of claims 5 to 7, characterised in that all said sensor means are housed within a single sensor body (3, 9).

9. A hub unit as claimed in claim 1, characterised in that said stationary support element is the axle box housing (1) or a cover member (15) closing said housing from the outboard side.

WO 00/51869

PCT/EP00/01690



WO 00/51869

PCT/EP00/01690

2/3

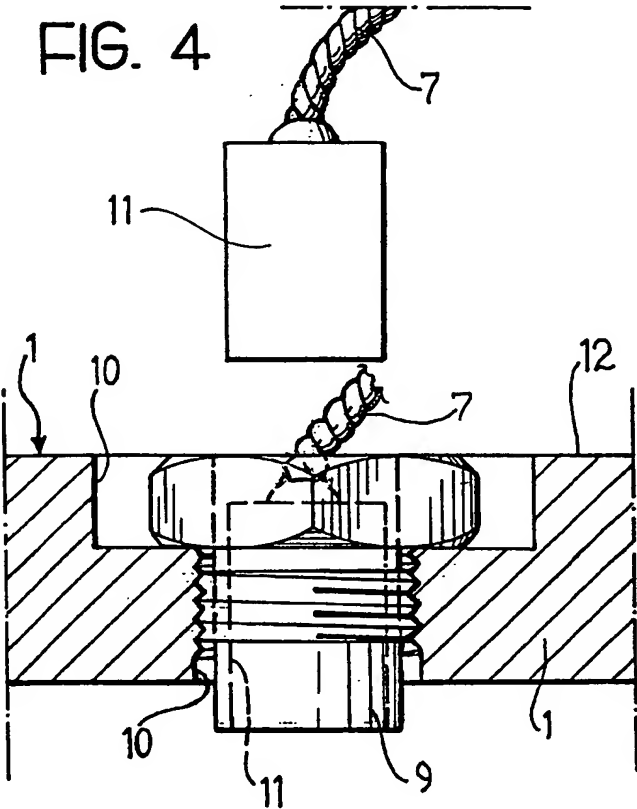


FIG. 5

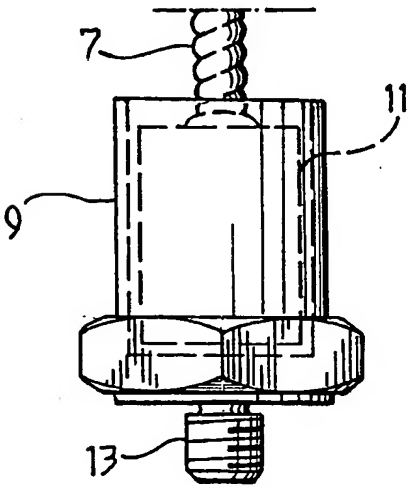
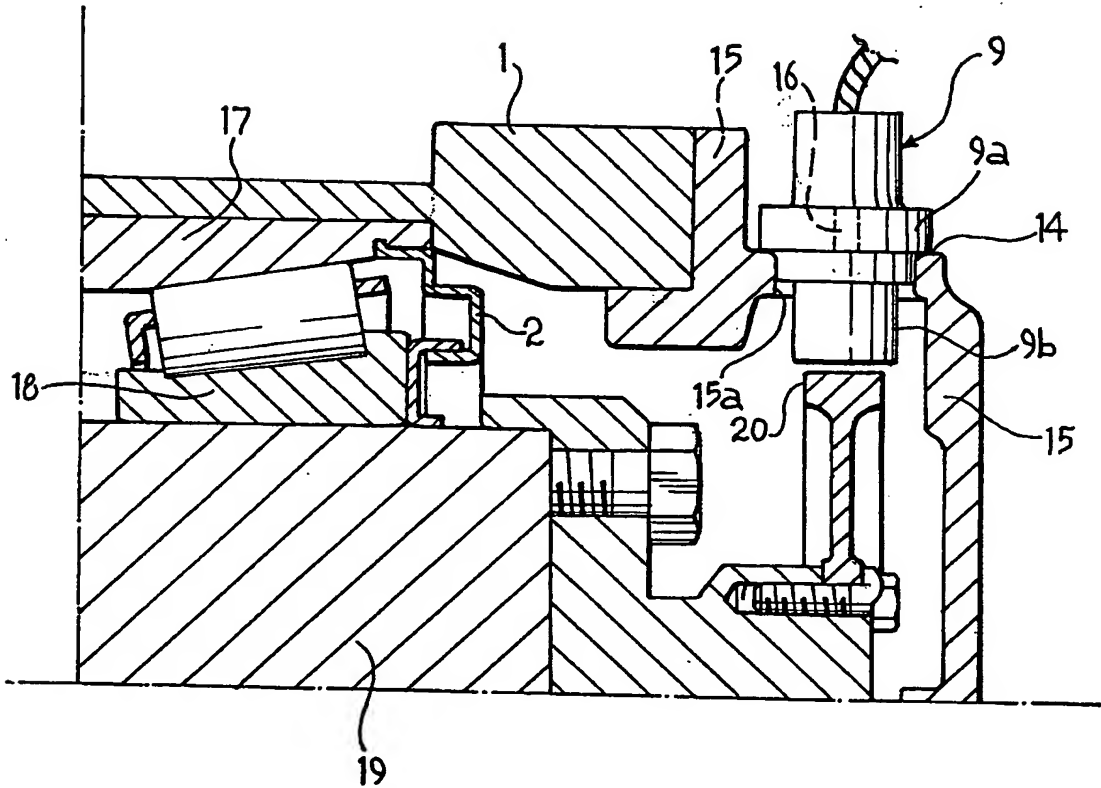


FIG. 6



INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 00/01690

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B61K9/12 B61K9/04 B61F15/20 G01M13/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B61K B61F G01M B60B B60T

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 98 11356 A (TALAFIOUS JOSEPH A ;TIMKEN CO (US); MELVIN JASON W (US); FRENCH MIC) 19 March 1998 (1998-03-19) page 3, line 14 -page 15, line 13; figures 1-8	1
Y	DE 197 30 212 A (SAB WABCO KP GMBH) 11 February 1999 (1999-02-11) the whole document	1
Y	WO 97 22095 A (SECURITY OPERATING SYSTEMS INC ;SMITH CHARLES C (US); BERNARD THOM) 19 June 1997 (1997-06-19) page 5, line 7 -page 8, line 27; figures 1-3	1
	-/--	

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

* Special categories of cited documents :

A document defining the general state of the art which is not considered to be of particular relevance

E earlier document but published on or after the international filing date

L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

O document referring to an oral disclosure, use, exhibition or other means

P document published prior to the international filing date but later than the priority date claimed

T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

Z document member of the same patent family

Date of the actual completion of the international search

30 May 2000

Date of mailing of the international search report

06/06/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Chlosta, P

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 00/01690

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 2 173 865 A (COAL IND) 22 October 1986 (1986-10-22) the whole document	1
A	GB 1 514 792 A (NIPPON SEIKO KK) 21 June 1978 (1978-06-21) page 2, line 3 - line 62; figures 1-3	1
A	US 3 745 815 A (BENTONE P ET AL) 17 July 1973 (1973-07-17) the whole document	1

INTERNATIONAL SEARCH REPORT

information on patent family members

International Application No

PCT/EP 00/01690

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9811356 A	19-03-1998	AU 4345997 A CN 1230245 A EP 0925456 A	02-04-1998 29-09-1999 30-06-1999
DE 19730212 A	11-02-1999	NONE	
WO 9722095 A	19-06-1997	US 5691707 A	25-11-1997
GB 2173865 A	22-10-1986	NONE	
GB 1514792 A	21-06-1978	JP 1251684 C JP 51008990 A JP 59009842 B FR 2278074 A GB 1514791 A US 4007630 A	14-02-1985 24-01-1976 05-03-1984 06-02-1976 21-06-1978 15-02-1977
US 3745815 A	17-07-1973	DE 2151284 A FR 2111434 A GB 1304818 A	25-05-1972 02-06-1972 31-01-1973